

# Low Surface Field 805-MHz Pillbox Cavity

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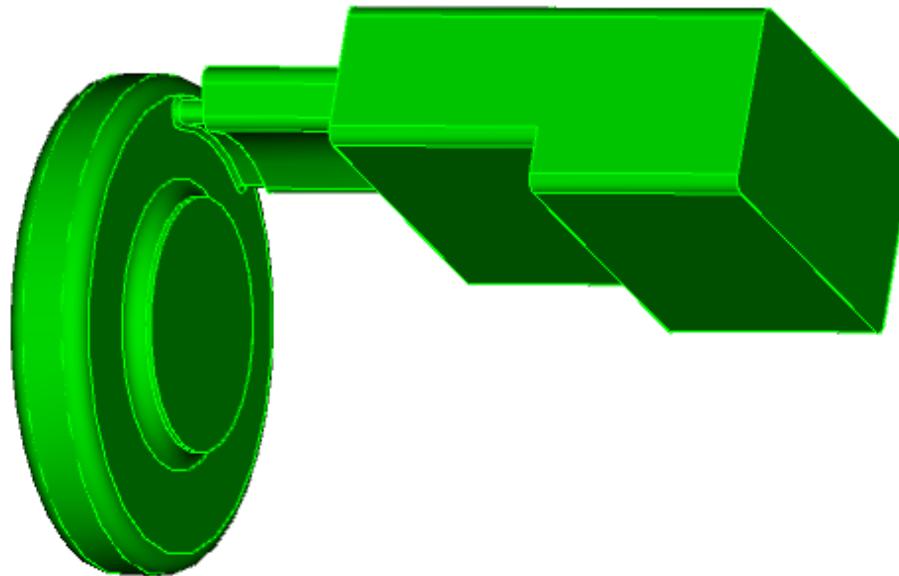
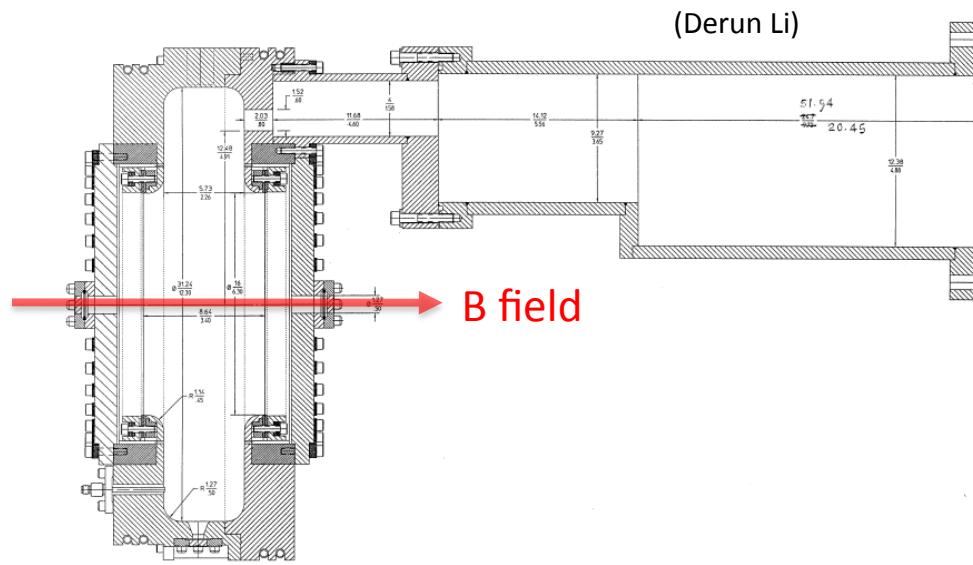
MAP 805-MHz Cavity RF, SLAC, March 23, 2012

# Outline

- New low surface field 805-MHz cavity design
- Multipacting comparison
- Field emission dark current analysis
- Summary

# 805-MHz Cavity

- Original Design



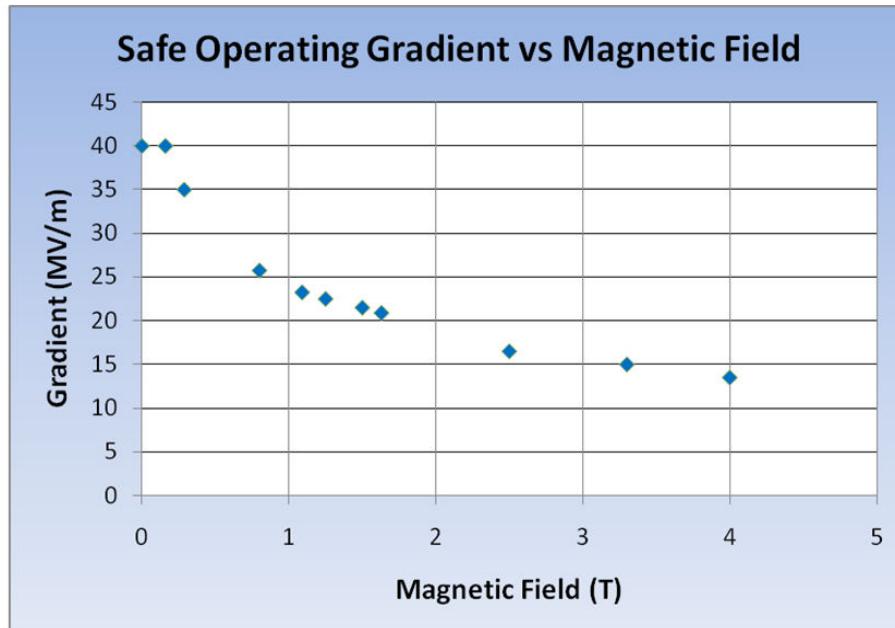
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# “Our” RF *Challenge*



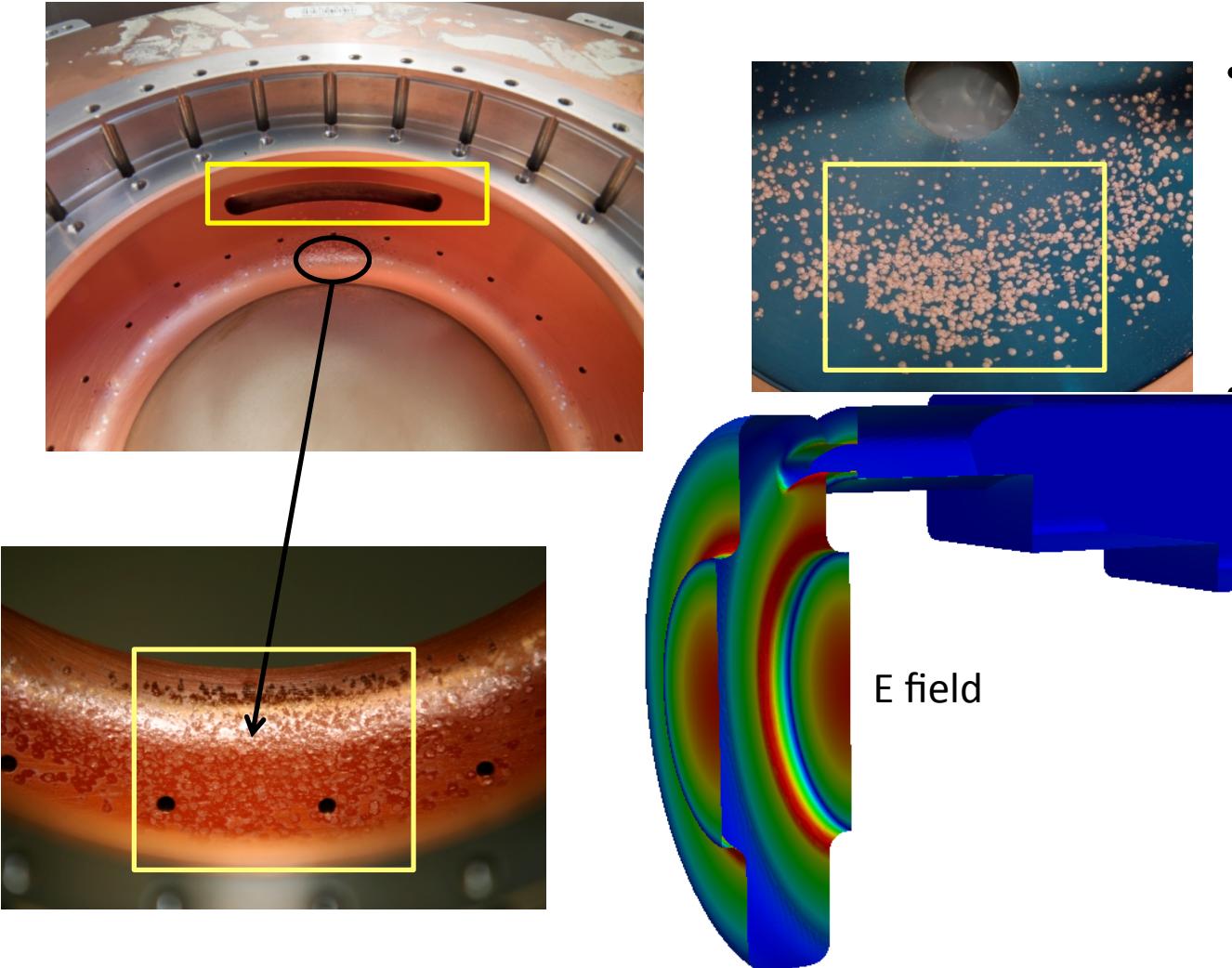
- Significant degradation in maximum stable operating gradient with applied B field

- 805 MHz RF Pillbox data
  - Curved Be windows
  - E parallel B
  - Electron current/arcs focused by B
- Degradation also observed with 201 MHz cavity
  - Qualitatively, quite different



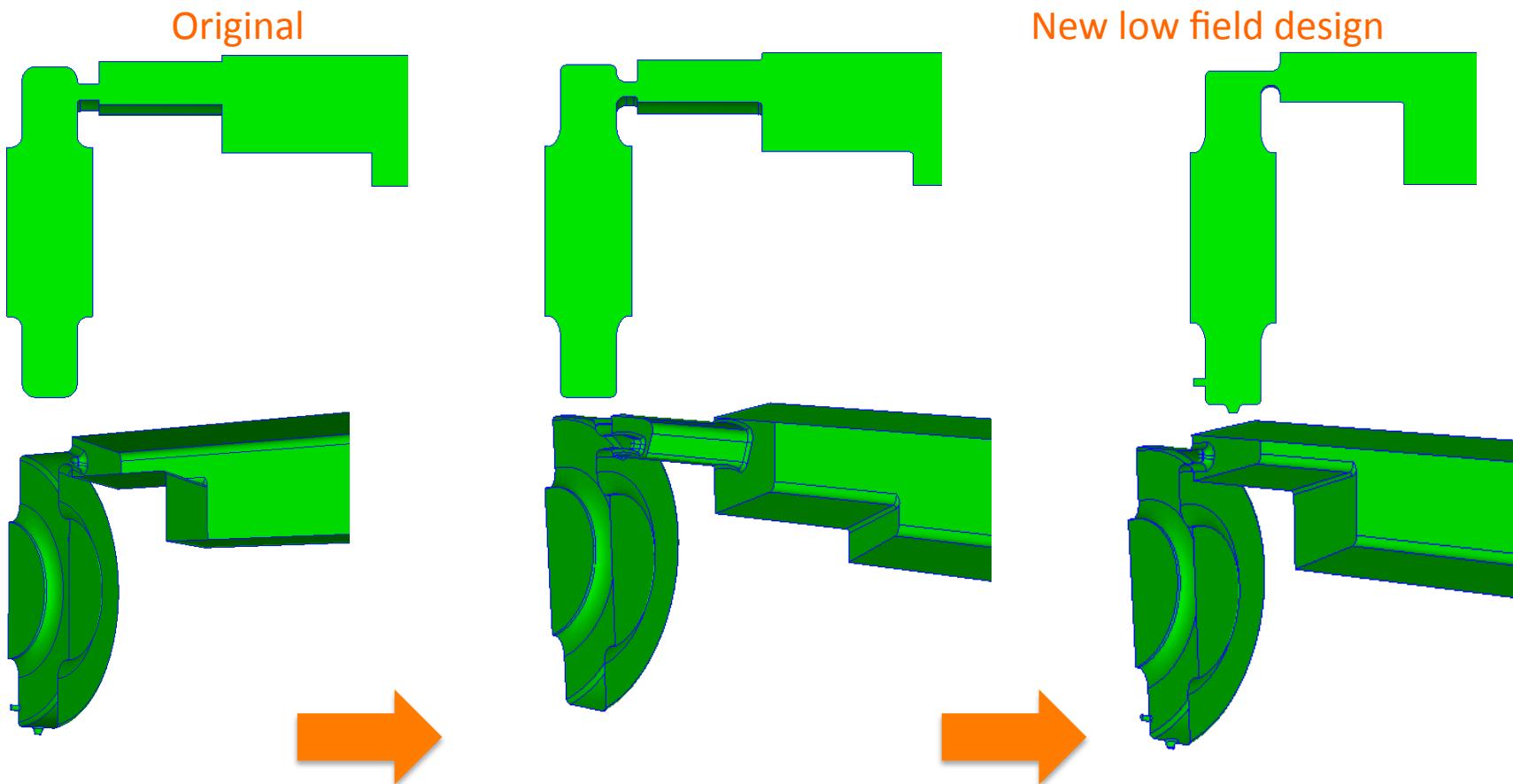
# 805 Pillbox

## *Post-Mortem*



- Significant damage observed
    - Iris
    - RF coupler
    - Button holder
- However
- No damage to Be window

# New Design with Improved Surface Field

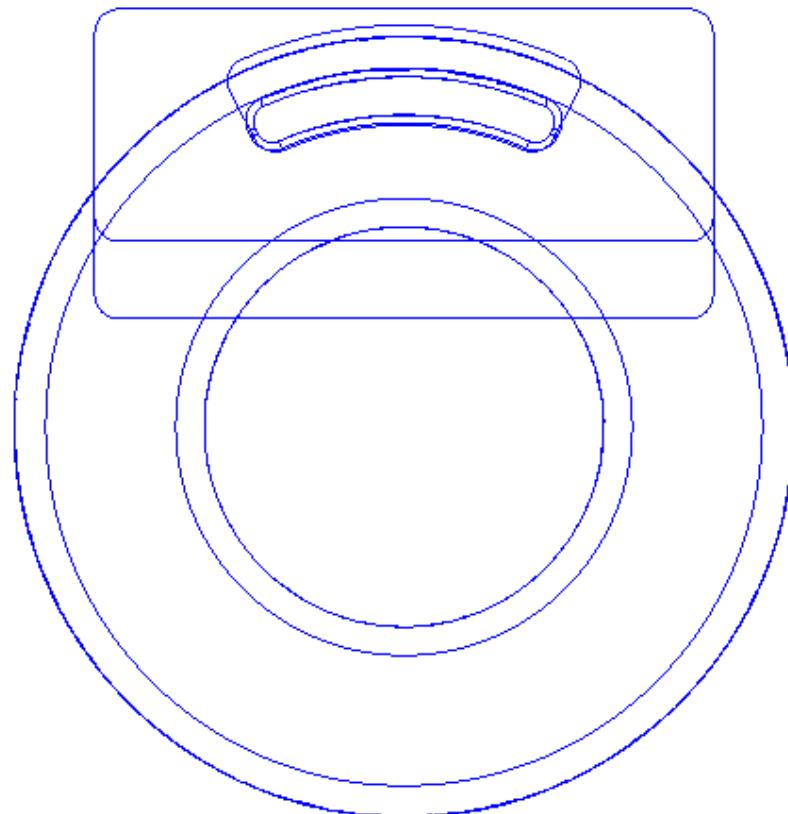


- Larger rounding around coupling slot
- Elliptical disk profile
- 40% surface field reduction

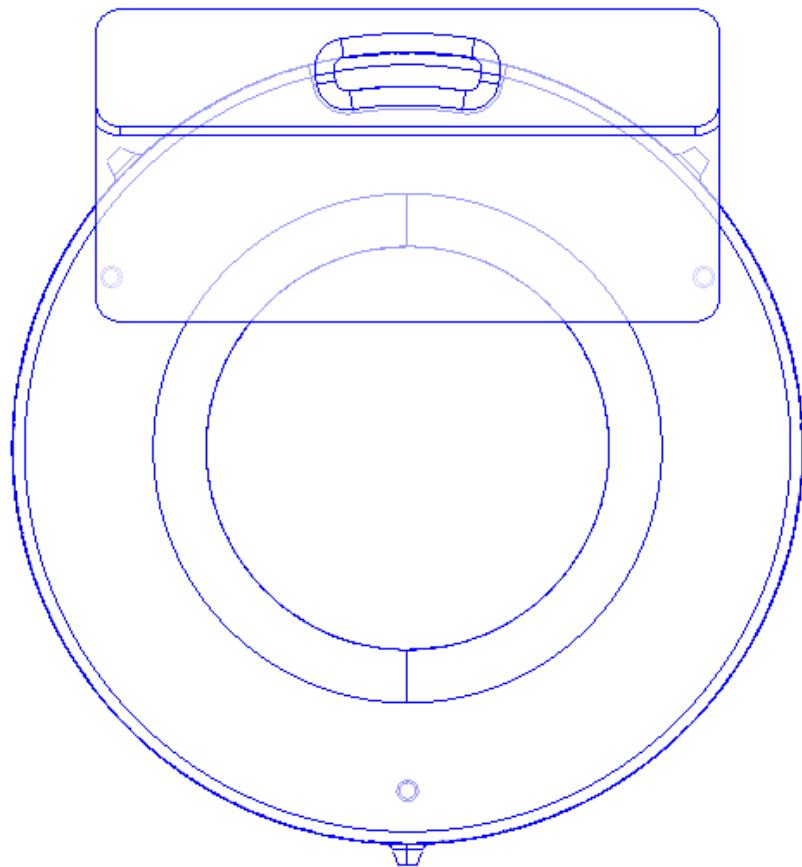
- Replaced cutoff wg with propagating wg
- Coupling at cavity outer radius
- Smaller opening – lower field
- Significant surface field reduction – Max E field on window surface

# Coupler Design Comparison

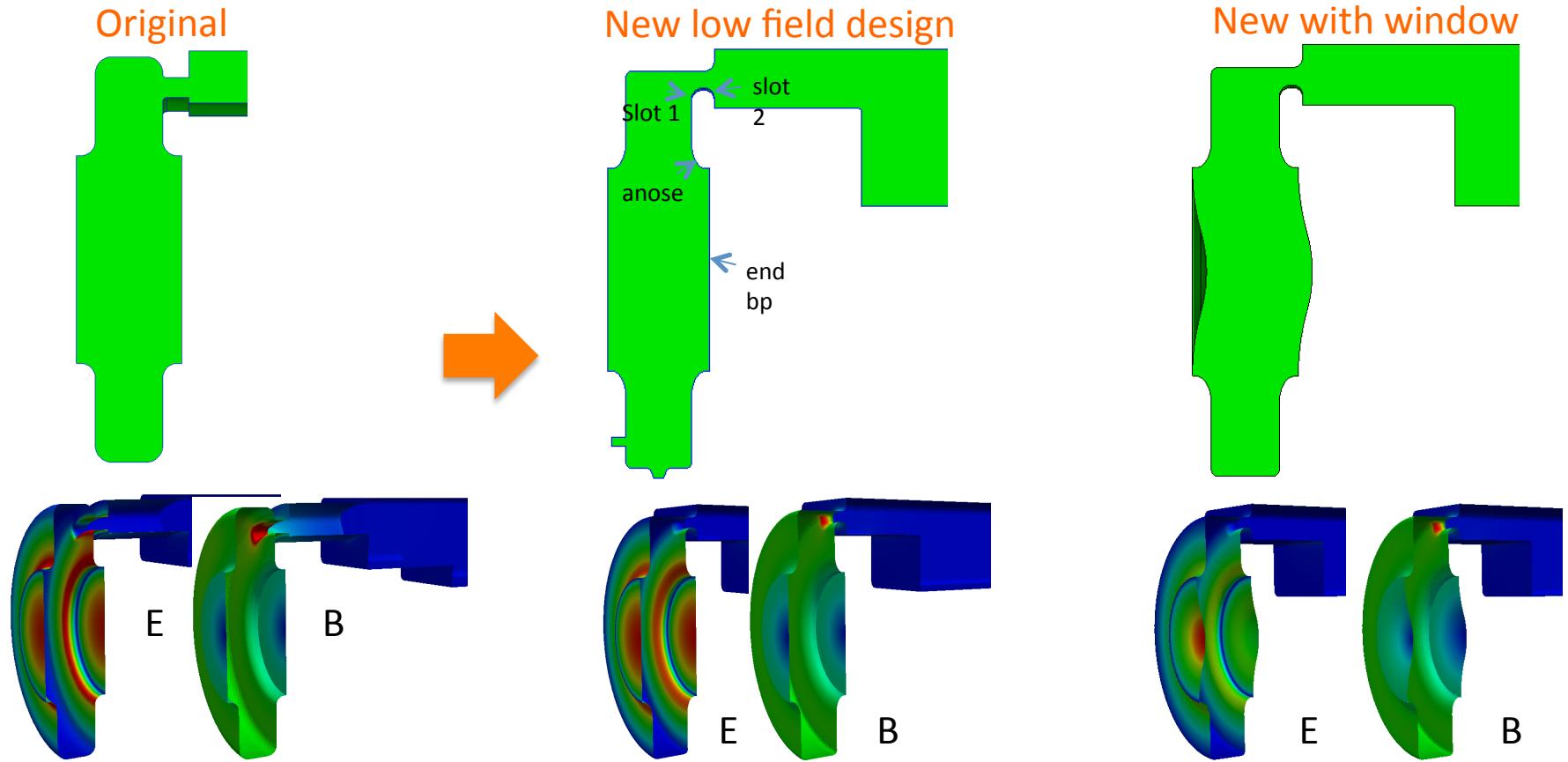
Original



New

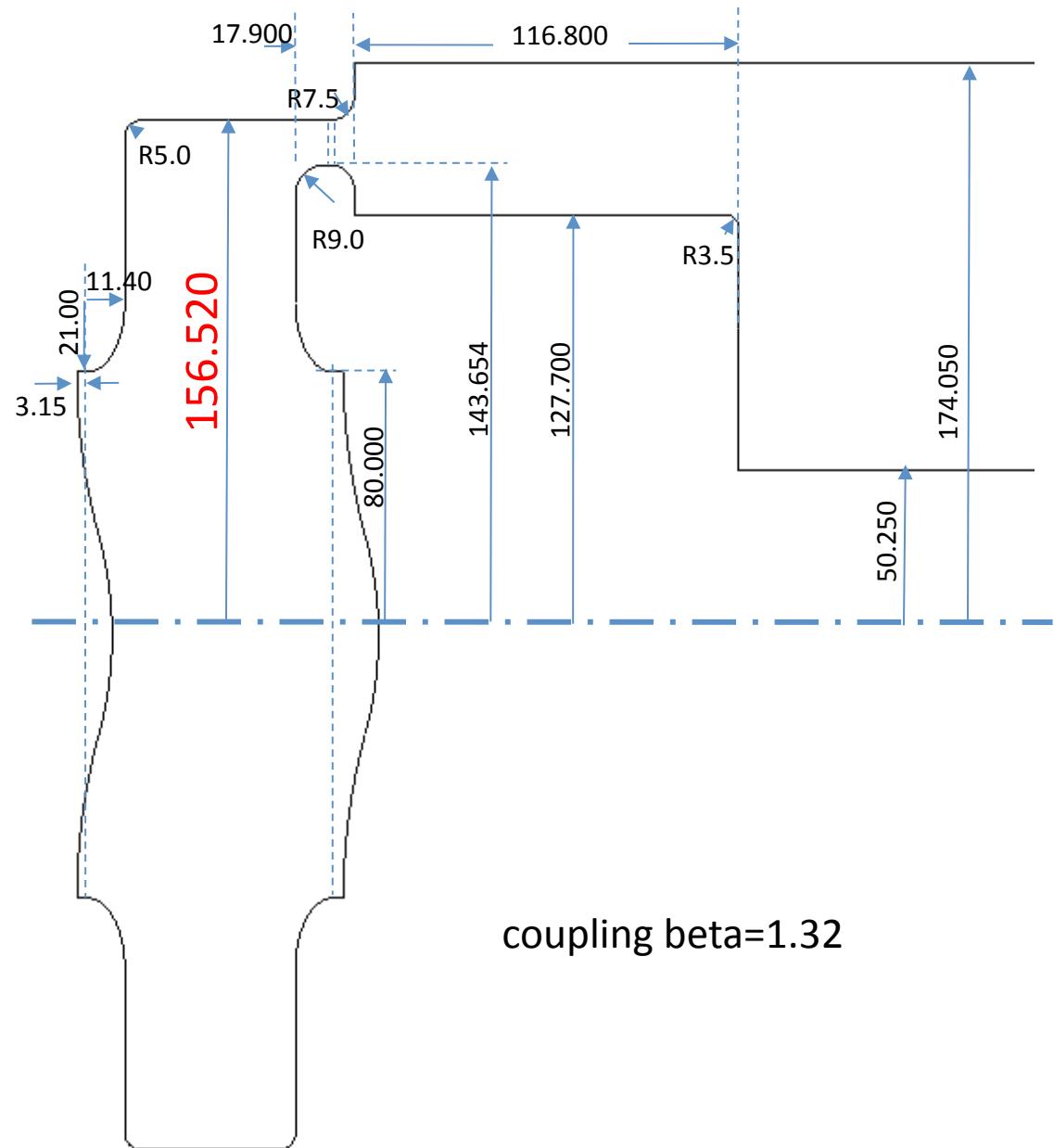
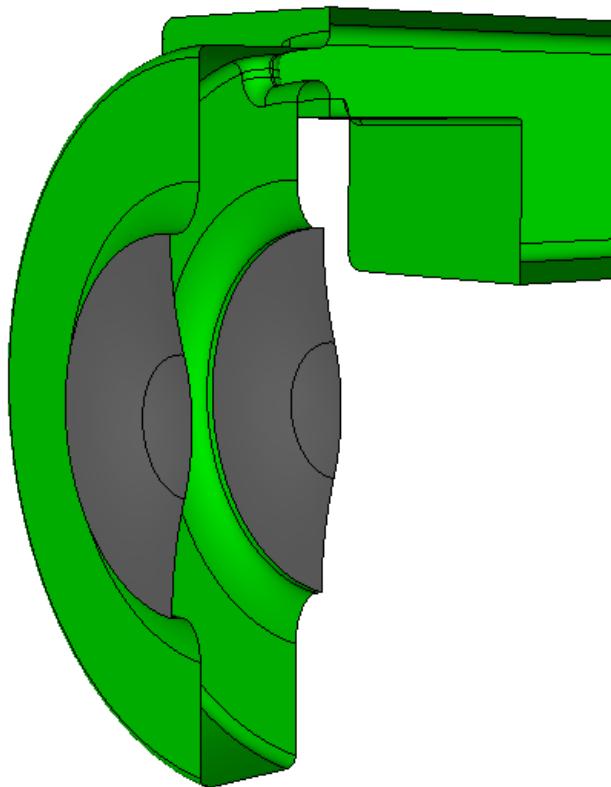


# New Design With Low Surface Field

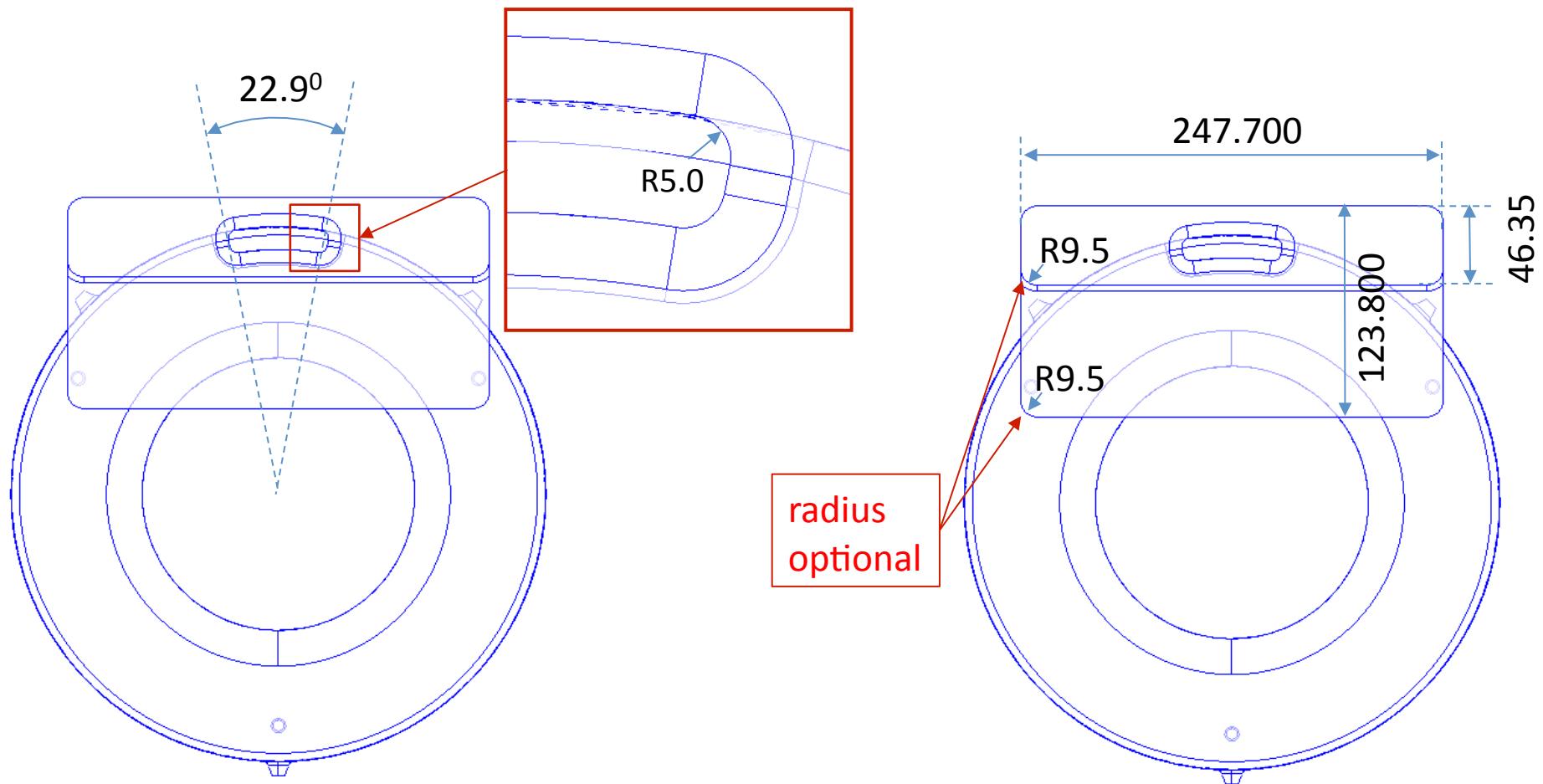


Model#	slot height	slot opening angle	slot rounding 1	slot rounding 2	disk anode	Emax on slot-1	Emax slot-2	Emax anode	Emax window	Hmax	Qext	Q0	beta
Original	15.2	53	3.175	0	11.4	69.81		44.95	32.88	0.304	12899	16007	1.24
NEW	13.5	22.2	9	7.5	21	16.09	8.40	31.75	33.38	0.122	15043	16761	1.11
New with window	13.5	22.9	9	7.5	21	16.26	8.93	33.27	48.24/27.68	0.124	12662	16717	1.32

# MAP 805-MHz Cavity With Window

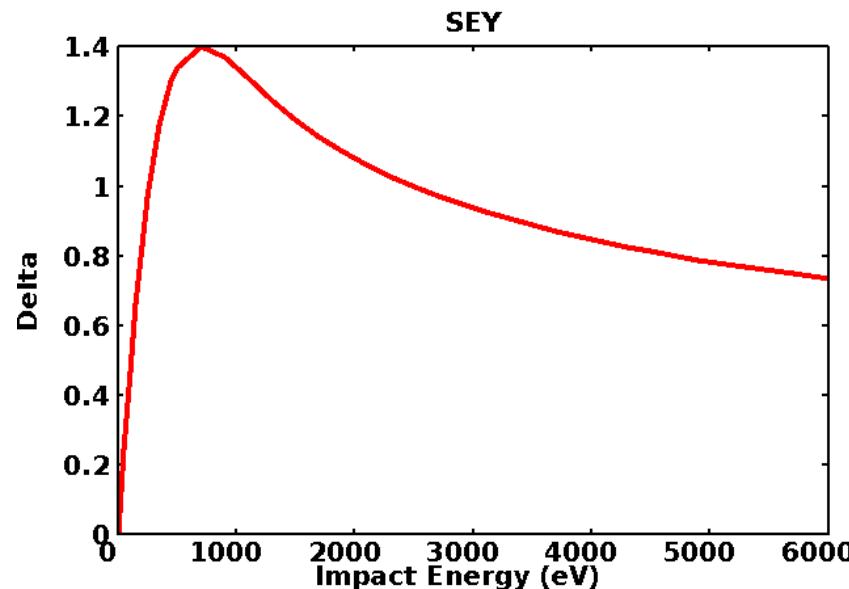


# MAP 805-MHz Cavity (beta=1.32)



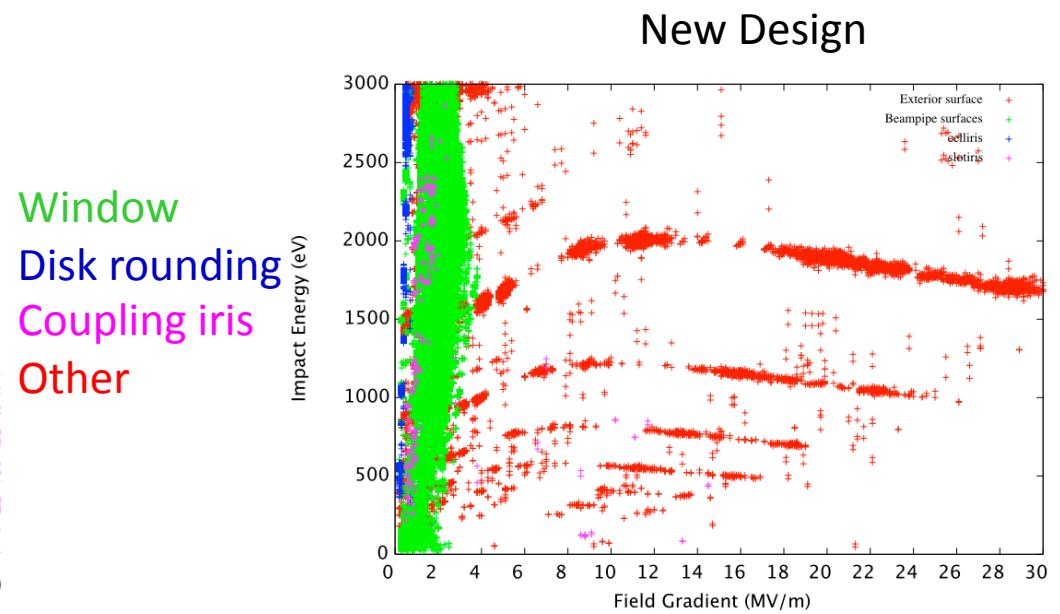
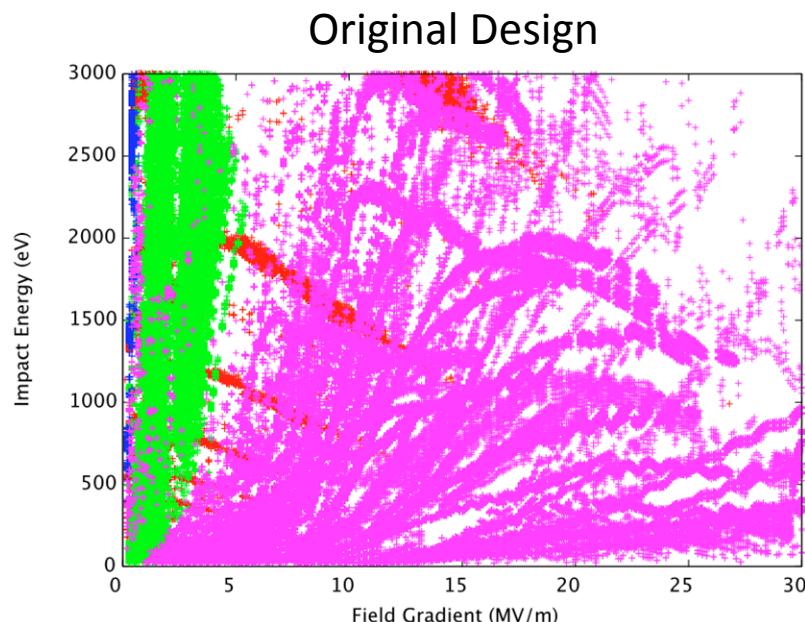
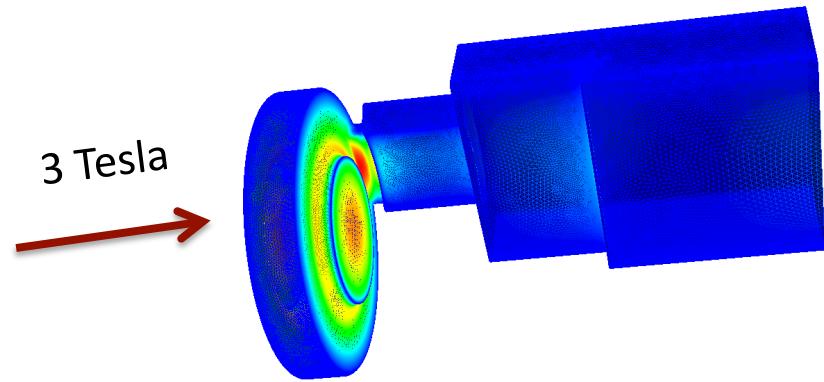
# Multipacting Simulation Using Track3P

- Part of ACE3P (Omega3P, S3P, T3P, Track3P, etc)
- 3D parallel particle tracking in high-order finite-element mesh
- Analyze resonant trajectories
- Use impact energy and SEY to estimate MP strength
- Copper SEY peak around 800eV impact energy

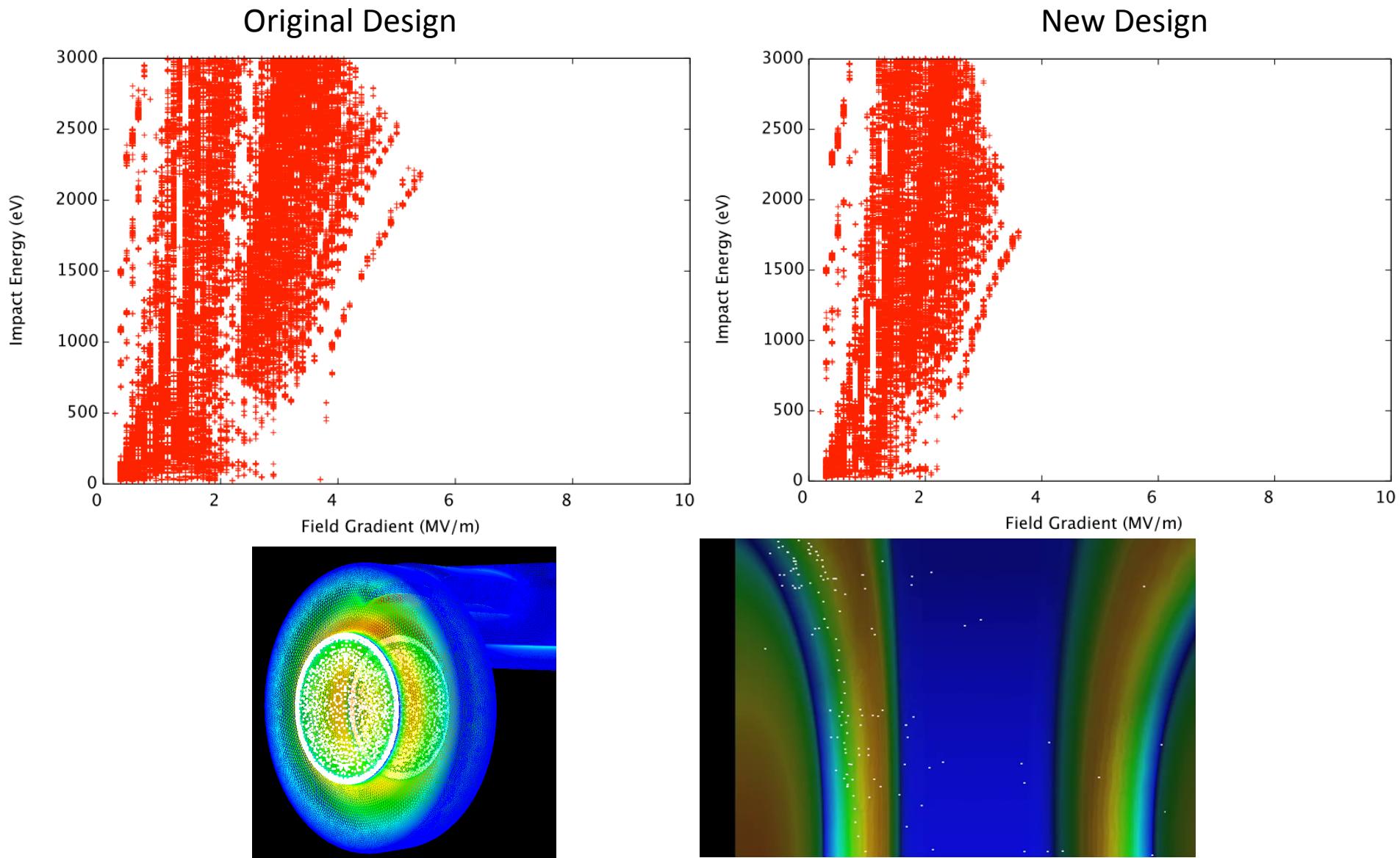


# Multipacting Analysis

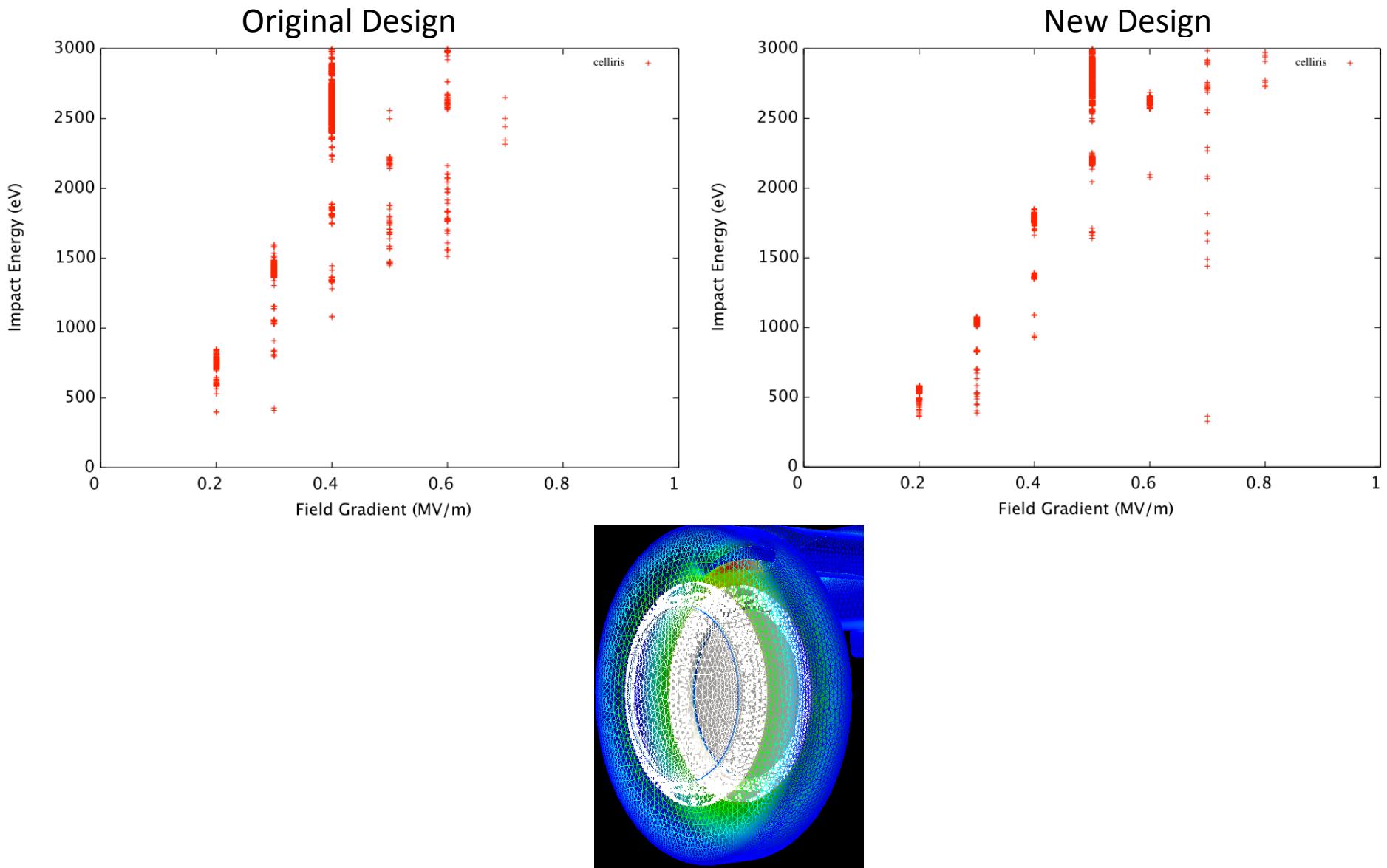
- Field level scan: 0.1MV/m – 30MV/m, interval 0.1MV/m
- Initial Particles distributed on all exterior surface
- Each field level ran 50 RF cycles



# Multipacting on Window Surface

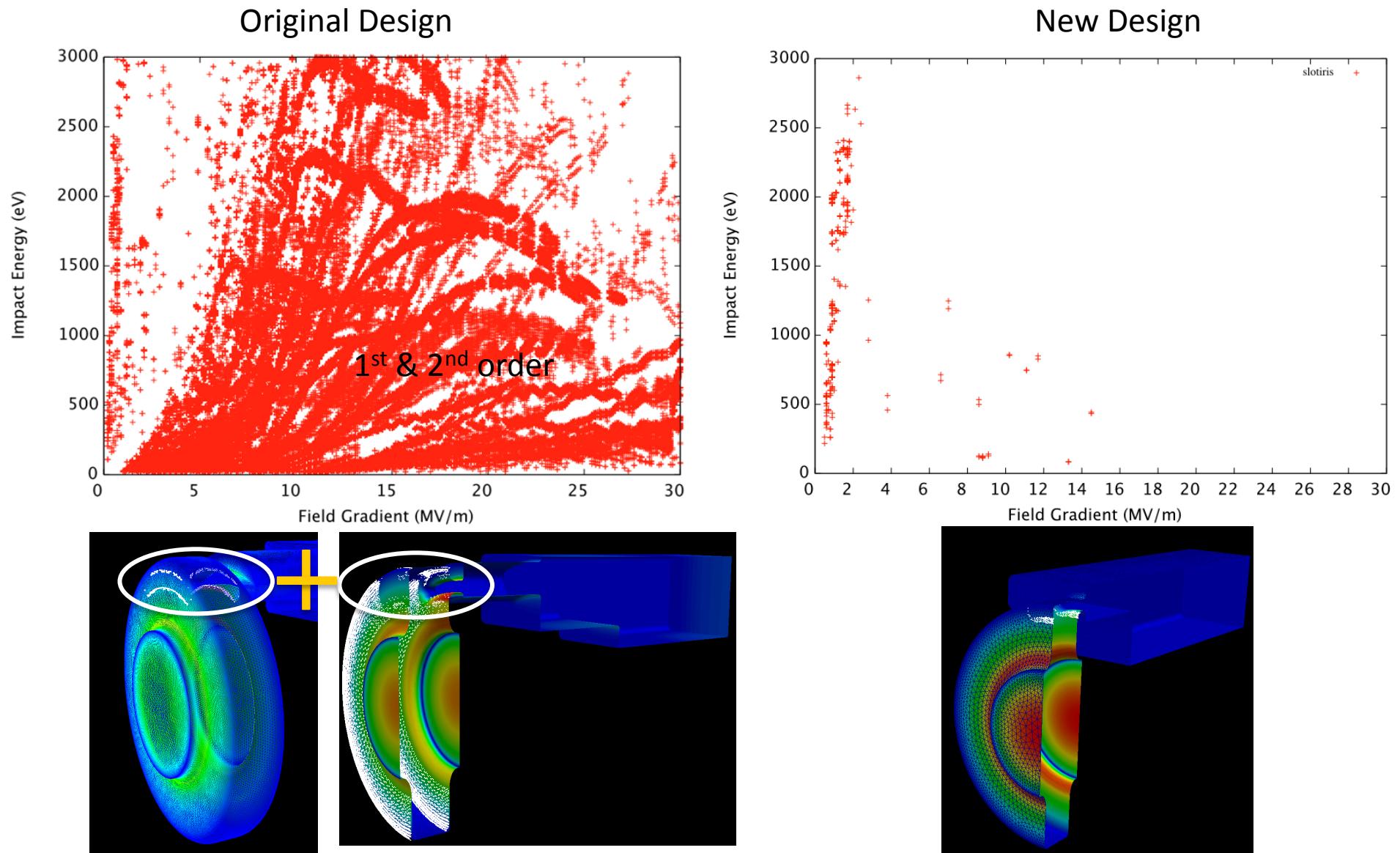


# Multipacting on Disk Rounding

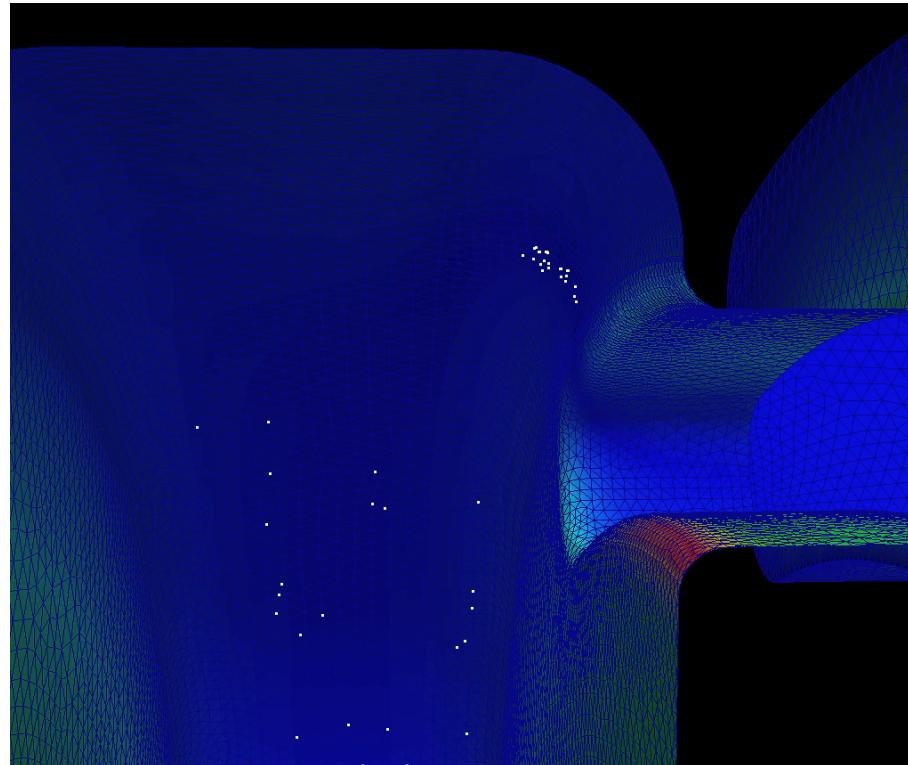


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# Multipacting on Coupling Iris

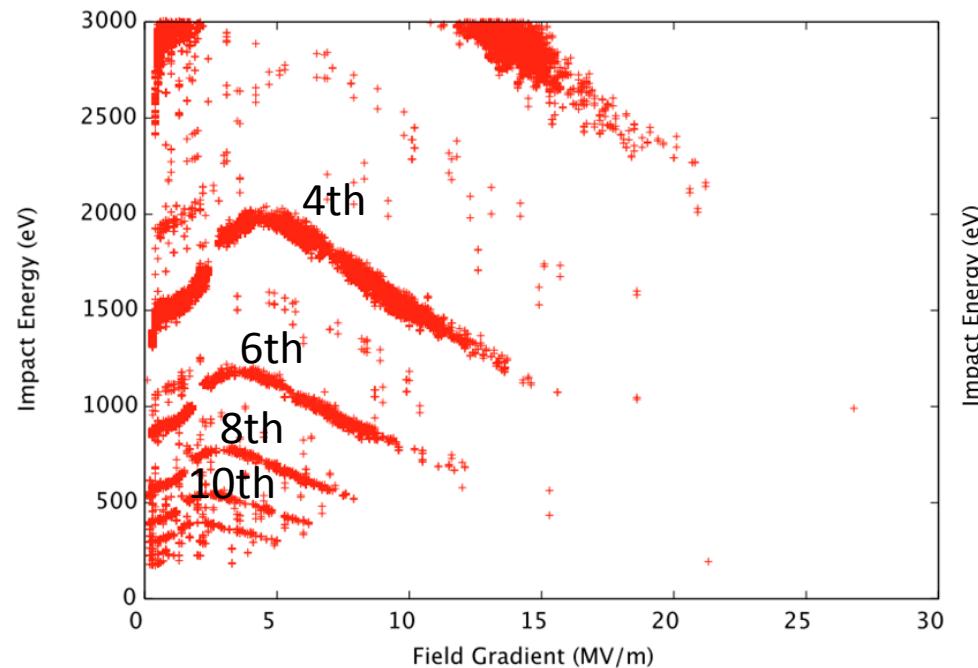


# Sample MP Trajectories Around Coupling Iris - Original Design

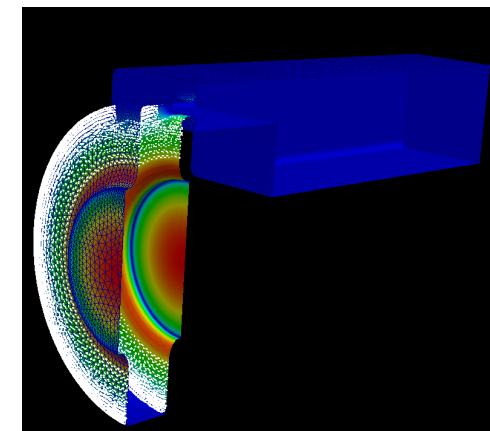
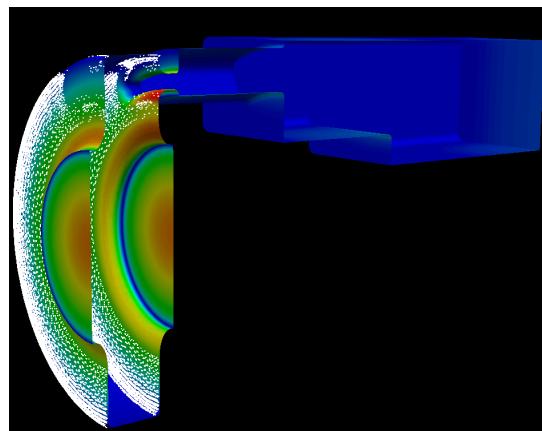
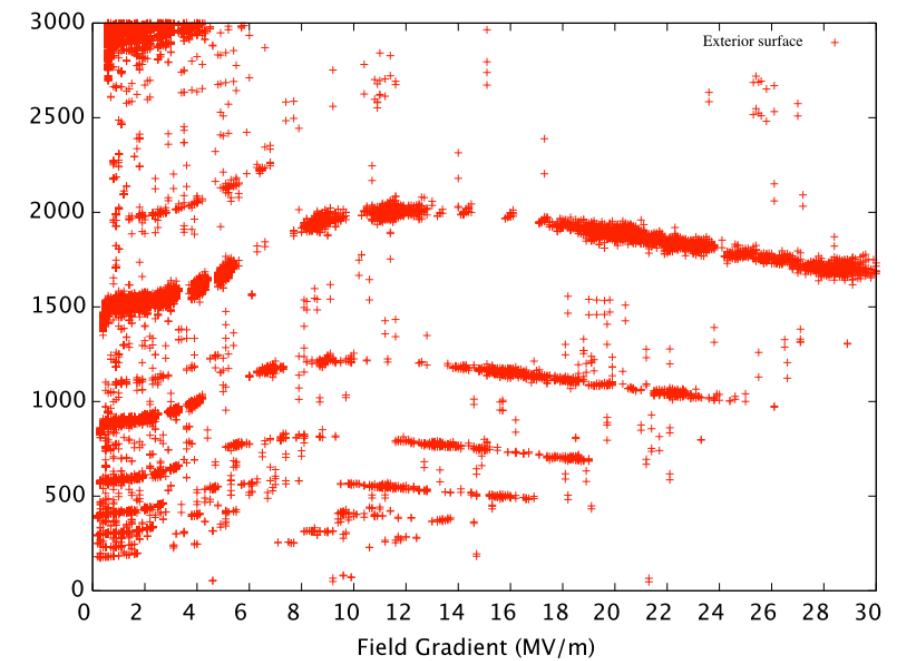


# Multipacting other exterior surface

Original Design



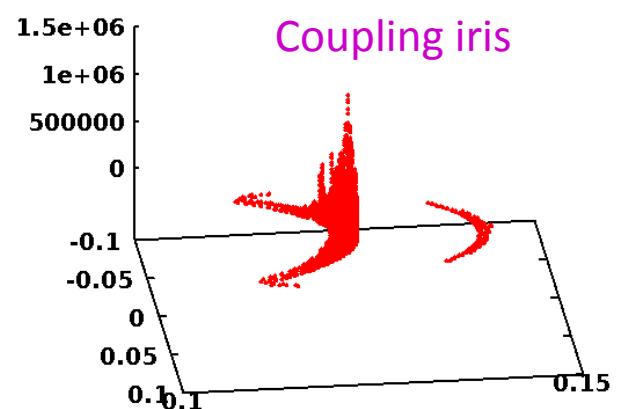
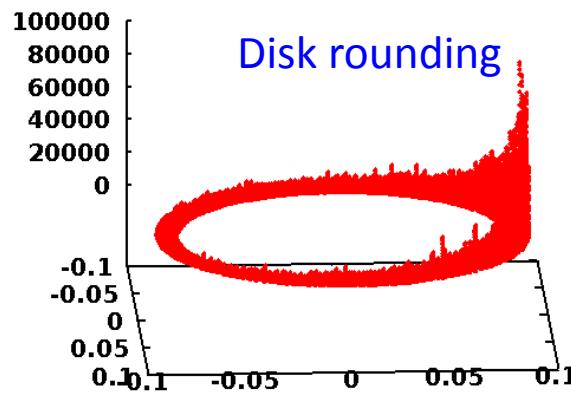
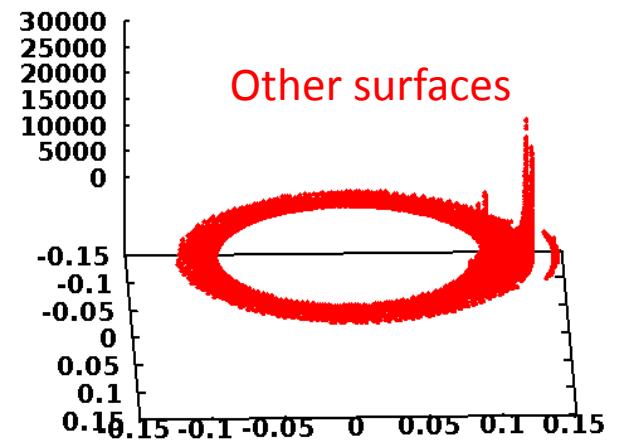
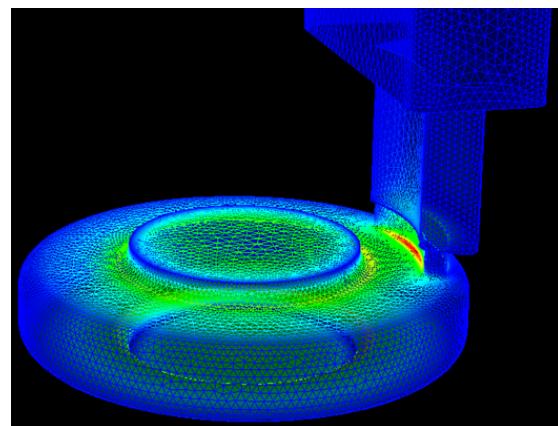
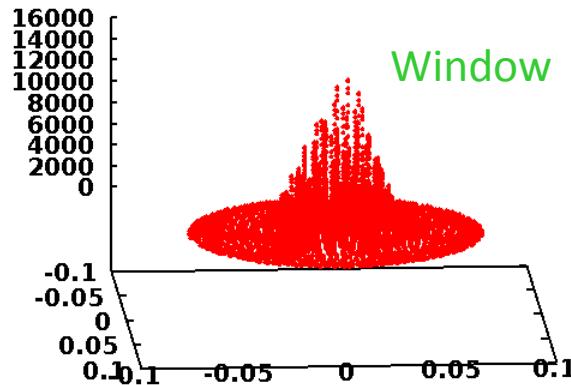
New Design



# Field Emission Simulation

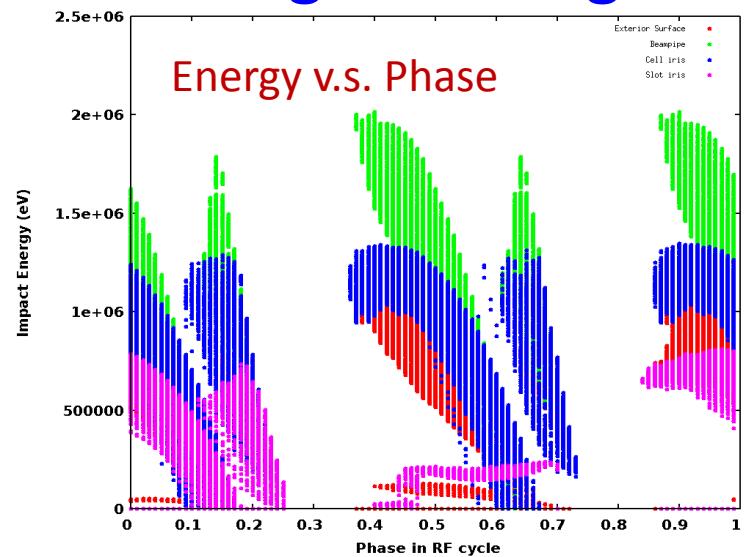
- Gradient: 25 MV/m
- Beta = 150 (normally use 50 for copper)
- Emitted all the surface based on Fowler-Nordheim field emission
- No secondary
- Quantity of interest (as function of rf phase)
  - Impact Energy of field emitted current
  - Current (relative quantity, depend on actual beta)
  - Distribution

# Dark Current Distribution – (original design)

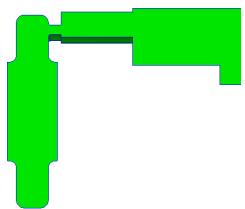
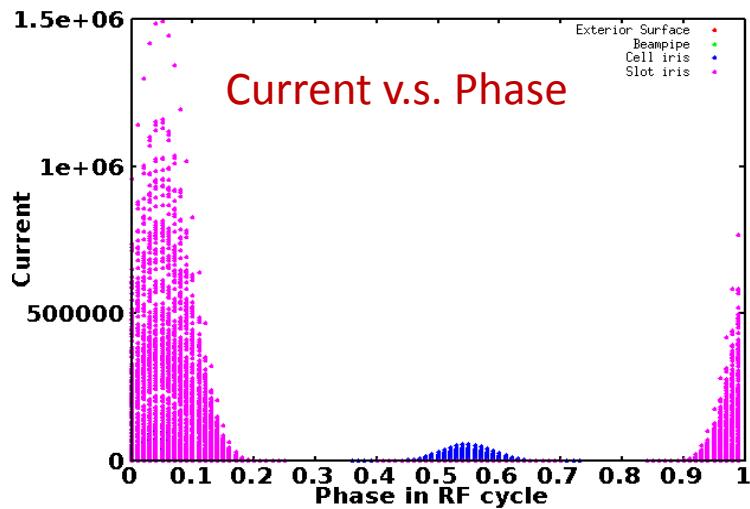


Field emission current corresponding to surface E field

# Original Design



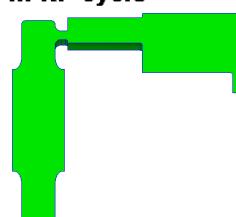
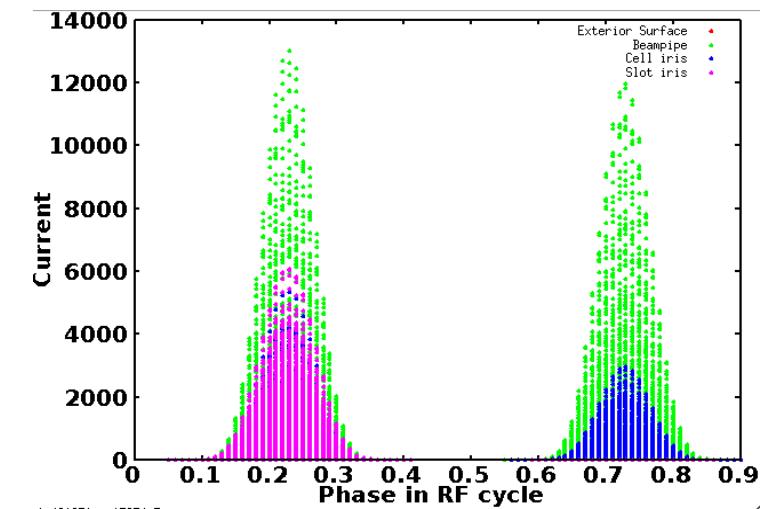
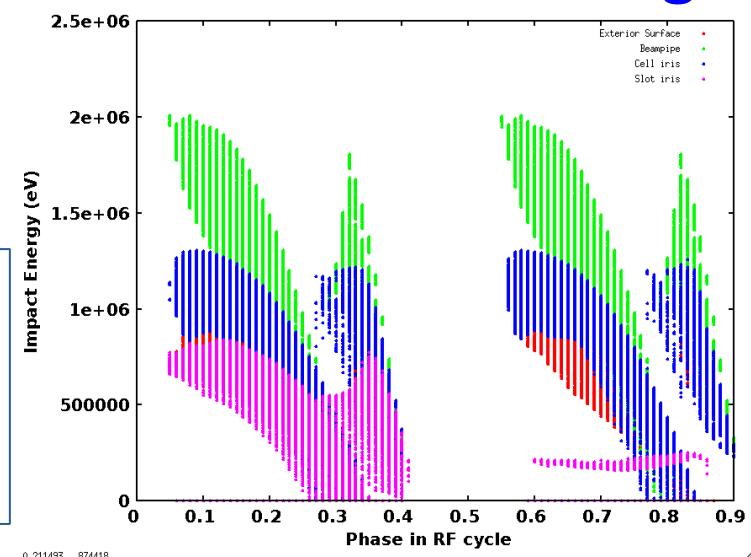
Window  
Disk rounding  
Coupling iris  
Other surfaces



I, E v.s. phase

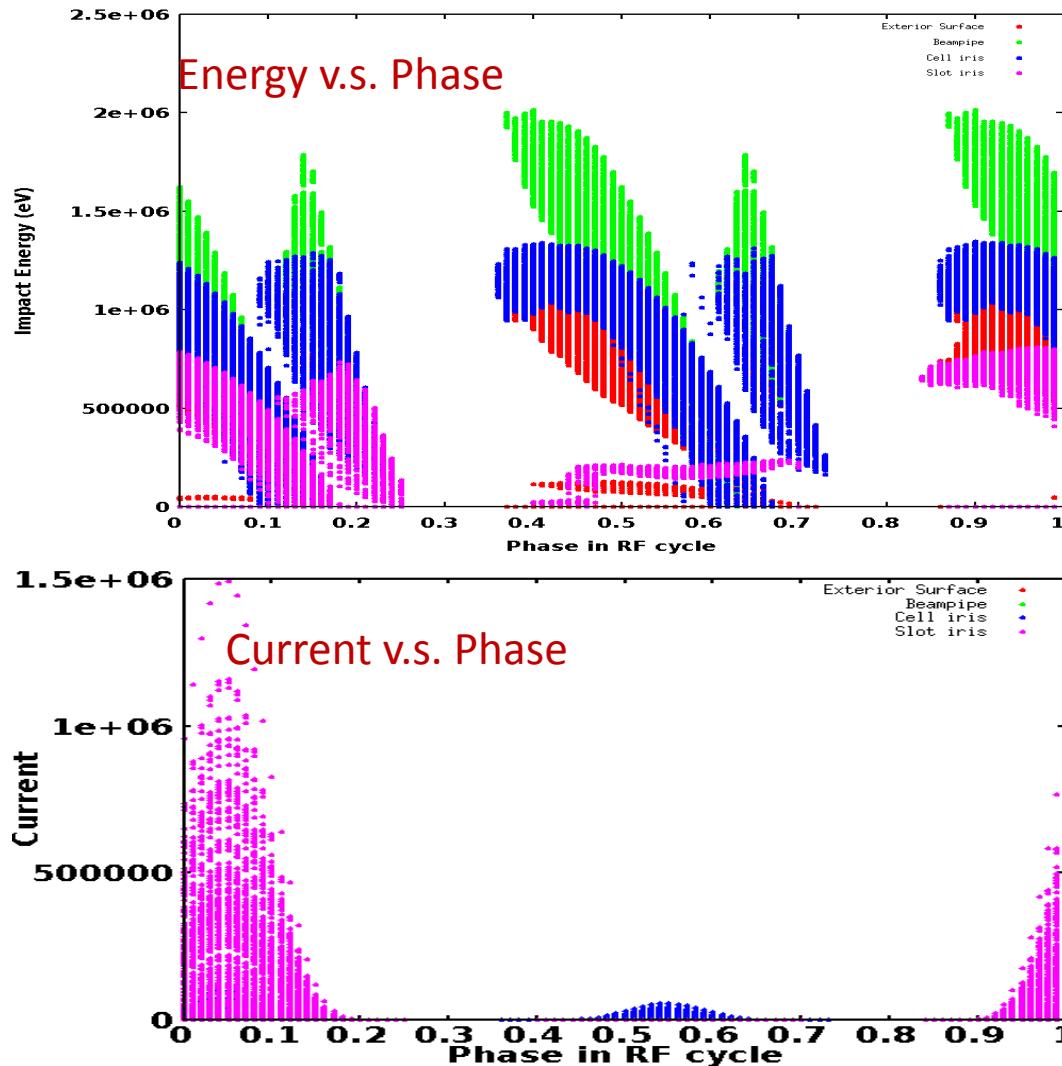
(relative rf phase between original and new is arbitrary)

# “Intermediate” Design



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# Dark Current Energy and Current (“a.u.”)



(relative rf phase between original and new arbitrary)

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Window  
Disk rounding  
Coupling iris  
Other surfaces

(New design only has field emission  
on window and disk rounding)

*High “E\*I” may result in  
“significant damage”*

# Summary

- New design significantly reduced field enhancement around the coupling slot. New high field region is on the window.
- Multipacting simulation indicated significant improvement in the coupling slot region.
- Field emission DC reduced as a result of low surface field.
- Numerical analysis a useful tool to help understand RF processing results.